

hospital within one month from the time of consulting a physician. Of these all but 3 were advised correctly. Average time, twenty-four weeks.

Time from onset of symptoms to time of entering hospital in those cases in which it was not stated when the physician was consulted, 90 cases, excluding those given above. Average time, fifty-five weeks.

#### PHYSICIAN'S ADVICE:

	Total.	Right.	Wrong.
Number curable . . . . .	43	32	11
Probably curable . . . . .	24	13	11
Incurable . . . . .	83	39	44
Operable . . . . .	74	51	23
Inoperable . . . . .	76	33	43

I wish to express my thanks to Dr. Charles L. Gibson for the privilege of publishing these statistics, as all the cases occurred in his service and were operated by him and the other members of the attending staff of the first surgical or Cornell division of the New York Hospital. I wish also to thank Dr. Morris Weeden for assistance in collecting the statistics and tabulating them.

### THE VIBRATING SENSATION IN DISEASES OF THE NERVOUS SYSTEM.

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THE "vibrating sensation" is the peculiar vibrating or trembling sensation which is felt when the foot of a *large* vibrating tuning-fork is placed firmly in contact with a subcutaneous bony prominence or surface in many parts of the body—the malleoli or the styloid process of the ulna or the sternum for example. The sensation is also sometimes described as bone sensibility or paresthesia. Attention was specially directed to this sensation by Egger in France in 1899. Many articles have been written on the subject in foreign medical literature and a few in English literature. In previous articles<sup>1</sup> I have pointed out the value of this sensation in diagnosis, and described the method of testing it.

In this article I shall record merely my own results in clinical work, since I first commenced to test the vibrating sensation in the routine examination of the nervous cases seventeen years ago.

A tuning-fork is supplied by Messrs. Woolley & Sons, Victoria Bridge, Manchester, which is very suitable for testing this sen-

<sup>1</sup> British Med. Jour., July 20, 1907: Diseases of the Spinal Cord, London, 1908, (1911), p. 79; Jour. Neurol., August, 1911; Lancet, February 9, 1918.

sation. It is seven and one-half inches long, marked A 440, and has an oval metal foot-piece (long diameter one and one-quarter inch) attached to it. Nearly all my observations were made with this tuning-fork.

A few control observations are desirable, to see if the patient clearly recognizes the nature of the sensation before a routine examination is made.

The vibrating sensation is felt when the foot of the vibrating tuning-fork is placed over the bones of the limbs, and on the nails, on the iliac spines, sacrum, vertebral spines and bones of the thorax. It is particularly well felt over the sternum. In clinical work convenient points for testing are the styloid processes of the ulna, the inner surface of the tibia, the malleoli, the anterior superior iliac spine and the nails of the fingers and big toes. In the normal condition the vibrating sensation is always felt at these points. The sensation is not felt on the bones of the skull, but the vibrations are heard.

Normally the vibrating sensation is also felt when the foot of the vibrating tuning-fork is placed *firmly* in contact with the anterior abdominal wall.

On the anterior abdominal wall, at the level of the umbilicus, the vibrating sensation (tested with the tuning-fork I have described at the commencement of this paper) is distinctly felt in the normal condition. Also it is distinctly felt on the abdomen between the umbilicus and the thorax. On the lower part of the abdomen (below the umbilicus) it is not felt so distinctly; but by *firm* pressure of the tuning-fork the sensation is usually felt.

In 50 consecutive cases (normal individuals, or cases of mild ailments not affecting the nervous system), the vibrating sensation produced by my tuning-fork was felt on the abdomen at all the parts just mentioned, both above and below the umbilicus. But occasionally in very *stout* persons I have found that the vibrating sensation cannot be felt on the abdomen.

**Conduction of the Sensation.** The nerve fibers conducting the vibrating sensation apparently do not decussate in the spinal cord. In many cases of unilateral lesion of the spinal cord the vibrating sensation has been lost only on the side of the lesion, below the level of the disease; whilst sensation for touch, pain, and temperature have been lost on the side opposite to the lesion.

The vibrating sensation is probably not conducted upwards in the gray matter, since the gray matter has been entirely destroyed in *hematomyelia* at the seat of the disease, and yet the vibrating sensation has been unaffected though the sensations for pain and temperature were markedly affected. (Bing)

In one of my cases of *syringomyelia* (of twenty years' duration) the vibrating sensation was normal though sensation for pain and temperature were lost on the hands and arms, and the hand muscles markedly atrophied.

Bing considers it probable that the vibrating sensation is conducted upwards in the posterior columns of the white matter of the cord.

In a considerable number of cases of spinal disease, which from their symptoms have been apparently cases of combined posterolateral degeneration, I have found the vibrating sensation lost and muscular sense impaired at an early period of the disease, while other forms of sensation have been normal at this period.

#### GENERAL REMARKS ON THE VALUE OF THE VIBRATING SENSATION IN DIAGNOSIS.

1. Loss of the vibrating sensation may be a useful indication of *organic affection of the nervous system* at the earliest stage of the disease, when symptoms and signs of such lesions are very few and slight—as at the earliest stage of peripheral neuritis, tabes, and posterolateral sclerosis. Sometimes in such cases, at the earliest stages, we may detect only one or two symptoms or signs in favor of *organic nervous disease*, and if we find the vibrating sensation lost, then this is an additional indication confirming our suspicions of commencing lesion of the nervous system.

2. Loss of the vibrating sensation is frequently one of the *first indications of sensory affection* in many lesions of the spinal cord and in peripheral *multiple neuritis*. In such cases the vibrating sensation is often lost before other forms of sensation are affected. At a later date anesthesia to tactile and painful sensations and to temperature may occur.

3. The vibrating tuning-fork is a very delicate *test for sensation*: and if we have found the sensation normal to touch, pain, temperature, etc., before concluding that sensation is entirely unaffected, it is desirable to test the vibrating sensation; since we may, as just mentioned, find it lost though otherwise sensation is normal.

4. When *partial recovery* occurs in cases of spinal lesions which have caused marked anesthesia the vibrating sensation may remain markedly affected though other forms of anesthesia have disappeared. Thus in a case of shrapnel wound of the spine, followed by complete paraplegia and anesthesia, with bladder symptoms, after laminectomy marked improvement followed. Two years later the patient was able to walk though the legs were spastic; the bladder symptoms had disappeared and sensations of touch, pain and temperature were felt distinctly; but the vibrating sensation was still lost on the legs.

In hemianesthesia from cerebral lesions we find that when recovery occurs the vibrating sensation returns *before* tactile sensation. Thus in a case of hemiplegia and hemianesthesia of sudden onset (probably due to hemorrhage), at first sensation, to the vibrating

tuning-fork and to all forms of sensibility was lost on the left side. At a later date, when marked improvement had occurred, the vibrating sensation and also painful sensations were felt on the left side; but sensation to touch was lost. This is thus the opposite of the condition in many cases of spinal anesthesia.

In spinal anesthesia the vibrating sensation is often the first to be affected and the last to recover; while in cerebral anesthesia the vibrating sensation may be the least affected, and if affected it may recover before tactile anesthesia. I have never met with a case of loss of the vibrating sensation alone in a cerebral lesion.

5. Certain diseases of the spinal cord affect only the motor parts of the cord. Anesthesia to any form of sensation would therefore exclude such diseases, or at least show that the pathologic changes had spread to the parts of the cord in which sensory structures are situated. Hence the detection of any affection of sensation is of great diagnostic value. But at first sensation to touch, pain and temperature may be normal; and until we test the vibrating sensation we may consider that the disease is localized entirely in motor parts. If, however, we find that the vibrating sensation is lost we have then an indication that the disease has affected sensory parts of the nervous system; and we can therefore exclude at once all diseases which are known to affect only motor parts of the nervous system. Thus in cases which we suspect to be anterior poliomyelitis or amyotrophic lateral sclerosis, we may exclude these diseases if we find the vibrating sensation lost.

6. The vibrating sensation is also sometimes of service in the diagnosis between paraplegia due to organic disease and paraplegia due to hysteria, functional affections or malingering. In any case of paralysis of the legs, if we find that the vibrating sensation is lost, while other forms of sensation are felt, and the patient persists in this statement in spite of suggestions to the contrary, then I think that hysteria or functional affection is very improbable. In paraplegia due to hysteria or functional affection or malingering my experience has been that if the vibrating sensation is lost other forms of sensation will also be affected, or that by suggestion, through the form of the question, the patients will state that they are affected.

7. The loss of the vibrating sensation on the abdomen may be of service in indicating the upper limit of a spinal lesion in traumatic and other spinal affections when other forms of sensation are not affected. Thus the vibrating sensation may be lost on the abdomen up to one inch above the umbilicus, while it may be felt on the abdomen above this level. This would be a guide to the level of the spinal lesion. (In testing, the foot of the tuning-fork should be pressed very firmly against the abdominal wall.)

THE DIAGNOSTIC VALUE OF LOSS OF THE VIBRATING SENSATION  
IN VARIOUS NERVOUS DISEASES.

In certain diseases of the nervous system affecting motor structure only the vibrating sensation is always felt. Thus I have never found it lost, even at an advanced stage of the disease, in cases of amyotrophic lateral sclerosis, primary lateral sclerosis, progressive muscular atrophy, acute and chronic anterior poliomyelitis (in the infant or adult) and paralysis agitans. Also I have never found it lost in pseudohypertrophic paralysis, idiopathic muscular atrophy, neurasthenia (unassociated with hysteria). Loss of the vibrating sensation would therefore be a strong point against the diagnosis of the affection just named.

The following remarks will indicate the value of the vibrating sensation in the differential diagnosis of various diseases.

At the earliest stage of *multiple peripheral neuritis*, from various causes, loss of the vibrating sensation may often be detected before loss of any other form of sensation. At this earliest period often the chief symptoms are pains in the legs and muscular tenderness, and it is often difficult to decide if these are due to commencing *organic* disease or not. On examination at this earliest period no anesthesia to tactile impressions, pain or temperature may be detected, and though the patient may complain of weakness in the legs, no definite paralysis or paresis may be detected. Also the knee-jerks may, at this *earliest* period, be still obtained. But in these cases two symptoms may be frequently detected which clearly indicate commencing *organic* disease; these are loss of the tendo-Achillis reflexes and loss of the vibrating sensation. At a later period in these cases the knee-jerks disappear and muscular paralysis and loss of other forms of sensation may be detected. We have thus four very early signs of *multiple peripheral neuritis*: (1) Pain in the legs; (2) tenderness of the muscles; (3) loss of the tendo-Achillis jerks; (4) loss of the vibrating sensation.

These remarks apply to alcoholic neuritis, arsenic neuritis, diabetic neuritis and multiple neuritis of other forms.

*Nervous Complications in Diabetes Mellitus.* In diabetes pains in the legs and tenderness of the calf muscles are not infrequent symptoms and are usually attributed to slight diabetic multiple peripheral neuritis, but paresis or paralysis is very rare. In these diabetic cases we often find that the tendo-Achillis reflexes are lost, and less frequently the knee-jerks also, and that the vibrating sensation is lost, though other forms of sensation are felt. In these very early cases of nervous complications, at first, only one of these symptoms may be present. Thus pain may be the only nervous symptom or loss of the tendo-Achillis reflexes or loss of the vibrating sensation, while later all these three symp-

toms may be present and additional symptoms may develop. I have found occasionally, in diabetic patients, that the vibrating sensation has been lost on the legs, even when the knee-jerks and tendo-Achillis reflexes have been present and the patient has not suffered from pain in the legs except cramp in the calf muscles at night. In other early cases and much more frequently, two of the symptoms just named have been present—pain and loss of the vibrating sensation or loss of the vibrating sensation and loss of the tendo-Achillis reflex or pain and loss of the tendo-Achillis reflex. Hence we may say that in diabetes mellitus the vibrating sensation is occasionally lost on the legs (malleoli and inner surface of the tibia) when other nervous symptoms are absent or slight. But the additional early symptoms just mentioned usually develop soon and others may develop later.

In 100 consecutive cases of diabetes I found the vibrating sensation was lost on the legs (malleoli and inner surface of the tibia) in 18 cases.

In a few of the cases of diabetes presenting these nervous symptoms usually described as "neuritis," pathologic examination has revealed changes in the peripheral nerves, but not always. I have found (in a case which I have recorded) that the peripheral nerves showed no definite microscopic changes (in the fibers examined); the posterior nerve roots, however, showed marked degeneration at their entrance into the cord directly after passing through the pia mater.

Loss of the vibrating sensation is often a useful sign in the differential diagnosis of multiple peripheral neuritis from acute anterior poliomyelitis affecting both legs, since in the later affection the vibrating sensation is not lost.

The symptom was of particular service in a case which I saw at the end of the war period. A man had been invalided home from France; paralysis of the legs had developed and slight paresis of the arms. The knee-jerks and tendo-Achillis reflexes were lost; the bladder was unaffected. Sensation to touch, pain and temperature could be felt. A diagnosis of spinal-cord affection and a very unfavorable prognosis had been given previously. On examination anterior poliomyelitis appeared very probably, as pain and muscular tenderness in the limbs had not been prominent symptoms, though both were present. But three symptoms were against the diagnosis of anterior poliomyelitis (subacute or acute):

- (1) The vibrating sensation was lost on the legs;
- (2) the paralysis in the arms was more similar in its distribution to that of peripheral neuritis than to anterior poliomyelitis;
- (3) The intercostals were not paralyzed, though both arms and legs were affected.

Chiefly on account of the loss of the vibrating sensation I gave a diagnosis of multiple peripheral neuritis and a favorable prognosis. In the course of many months complete recovery occurred.

In *sciatica* and in *primary brachial neuritis* I have never detected loss of the vibrating sensation.

In lesions of a *single peripheral nerve* or a *peripheral nerve trunk* I have never found the vibrating sensation lost, when tested with the tuning-fork I have described in this article, even though other forms of sensation (to touch, pain or temperature) have been affected. Occasionally I have found the vibrating sensation much diminished but never lost, and in most cases it is felt quite well. This is a point sometimes of service in differential diagnosis. In a case of localized paralysis (whether other forms of sensation are lost or recognized), if the vibrating sensation is *completely* lost a lesion of a *single peripheral nerve* or *nerve trunk* can be excluded as the cause of the paralysis.

In *acute anterior poliomyelitis* of the infant and adult the vibrating sensation is unaffected. This fact is occasionally of much service, as already mentioned, in the diagnosis between multiple peripheral neuritis and acute anterior poliomyelitis causing paralysis of both legs. Usually the pain and muscular hyperalgesia in peripheral neuritis is so pronounced that the diagnosis is easy, but we have to bear in mind that occasionally in acute anterior poliomyelitis at first some pain and muscular tenderness may occur, and occasionally in peripheral neuritis these two symptoms are not very pronounced at first. The loss of the vibrating sensation would be in favor of multiple peripheral neuritis and would show that sensory structures in the nervous system were affected, and that the case was not one of acute anterior poliomyelitis.

In the diagnosis between acute anterior poliomyelitis and *acute disseminated myelitis* or *acute myelitis* the vibrating sensation is helpful. All three diseases may cause paralysis of both legs, and at first sensation to touch, pain and temperature may be normal in acute disseminated myelitis or acute myelitis, as well as in acute anterior poliomyelitis, but in the two former affections the vibrating sensation is often lost. The vibrating sensation may then be of much service in the diagnosis; if lost, acute anterior poliomyelitis may be excluded.

I have found the vibrating sensation of much service in the diagnosis of acute anterior poliomyelitis from the two affections just named and from other spinal diseases, and have recorded cases.

In chronic (and subacute) anterior poliomyelitis the vibrating sensation is not lost, and this fact is occasionally of service in the differential diagnosis of these affections from multiple peripheral neuritis and other spinal cord diseases. Thus in two of my cases of slowly developing paralysis of the legs, with loss of the tendo-Achillis reflexes, the fact that even the vibrating sensation was unaffected (as well as other forms of sensation) was a point, along with others, in favor of chronic anterior poliomyelitis, and enabled

one to exclude many other diseases which might have produced similar motor symptoms.

Primary lateral sclerosis is certainly an *extremely rare* disease and can be excluded in any cases in which the vibrating sensation is lost. In all cases which appear to be instances of this rare affection the vibrating sensation should be tested before the diagnosis is given. In one of my cases of spastic paraplegia the fact that the vibrating sensation was present at the end of twenty years was one point, along with others, in favor of the diagnosis of primary lateral sclerosis. (In this case the bladder and rectum had not been affected, no wasting of hand muscles had developed, sensation was unaffected and no signs could be detected of affection of any part of the spinal cord except the lateral pyramidal tracts even at the end of twenty years.) In another case of spastic paraplegia of fifteen years' duration loss of the vibrating sensation, slight nystagmus and occasional diplopia were points against primary lateral sclerosis and in favor of disseminated sclerosis.

In *amyotrophic lateral sclerosis* the vibrating sensation is not lost even at the terminal stage of the disease. In any case of suspected amyotrophic lateral sclerosis, loss of the vibrating sensation would be evidence against this diagnosis.

In many cases which have presented the symptoms of *combined posterolateral spinal degeneration or sclerosis (ataxic paraplegia)* I have found the vibrating sensation lost at a very early stage of the disease. At first the symptoms have been chiefly slightly impaired coördination (slight ataxia), Babinski reflexes, impaired muscular power and loss of the vibrating sensation, while other forms of sensation have been felt. Later ankle-clonus and spastic condition of the legs have developed. In some of these cases at a later period sensation to touch, pain and temperature have been much affected. At the earliest stage the loss of the vibrating sensation is a valuable sign of commencing organic disease and is often of much service in diagnosing these cases from functional affections or malingering. I have recorded such cases elsewhere. I may mention one, however, which was of special interest:

A man consulted me in January, 1917, complaining of weakness and heaviness in the legs and slight unsteadiness in walking. He was called up for military service and considered that he was unsuitable on account of these symptoms. The question of malingering or neurasthenia had to be considered. I examined him very carefully, but could then detect no signs of organic disease. He was able to walk alone and showed only very slight unsteadiness, but complained that his legs felt heavy and weak.

In May, 1917, I again examined him and then detected (1) that the gait was slightly ataxic; (2) that the vibrating sensation was lost on the legs, but other forms of sensation were unaffected; (3) that the plantar reflexes were difficult to obtain, but several



times a Babinski reflex was obtained. No other signs of organic disease could be detected, but from the symptoms just named I gave a diagnosis of commencing spinal disease.

In November, 1917, I again examined him. Then the chief symptoms were: (1) definite paresis of the legs; (2) ataxic gait; (3) slight spastic condition of the legs; (4) knee-jerks increased and ankle-clonus and Babinski reflex on each side; (5) muscular sense greatly impaired; (6) vibrating sensation lost on both legs but other forms of sensation recognized. At this period there was no doubt as to the diagnosis of organic spinal disease, and posterolateral sclerosis or degeneration was very probable; but at the earlier examination in May the only definite indications of organic disease were the loss of the vibrating sensation and the occasional Babinski reflex.

I have had many spinal cases in which at first the chief symptoms have been: (1) loss of the vibrating sensation while other forms of sensation have been normal; (2) slight incoördination in walking or affection of the muscular sense in the legs, and (3) Babinski plantar reflexes. These cases have usually developed later marked symptoms of posterolateral degeneration (or sclerosis) ataxic paraplegia.

In *disseminated sclerosis* sensation is very often reported as normal, and this is probably correct as regards sensation for touch, pain and temperature; in other cases these sensations are definitely affected. But if the vibrating sensation be tested it will be found to be lost in a large number of cases of disseminated sclerosis, though other forms of sensation are felt distinctly.

In many cases of disseminated sclerosis I have found the vibrating sensation lost on the legs; in some cases lost on the lower half of the abdomen and also on the legs; in others on the whole of the abdomen and the legs. In a few cases the vibrating sensation has been lost on the middle or lower part of the abdomen but not on the legs and chest. In one case the vibrating sensation was lost only on one-half of the lower two-thirds of the abdomen.

The abdominal and epigastric reflexes are usually lost when the vibrating sensation is not felt on the abdomen in disseminated sclerosis.

In atypical cases of disseminated sclerosis, when the symptoms are chiefly those of spastic paraplegia, the case may closely simulate primary lateral sclerosis. But if we find that the vibrating sensation is lost this symptom would exclude primary lateral sclerosis and would be one point in favor of disseminated sclerosis. I have found this symptom sometimes of much service in diagnosis.

My own experience has been that in disseminated sclerosis, if sensation is impaired, *by far the most common form of impairment is loss of the vibrating sensation*, while other forms of sensation are felt; and that this condition is met with in a large proportion of the cases.

In *tabes dorsalis* at the very early stage the vibrating sensation is sometimes lost on the legs though other forms of sensation (to touch, pain and temperature) are normal. Hence in the diagnosis of *tabes* at the earliest stage, when the symptoms are few and slight, loss of the vibrating sensation may be of diagnostic value as additional evidence in favor of this disease.

In *hematomyelia* when sensation for pain and temperature have been markedly affected the vibrating sensation has been found unaffected, though the gray matter has been destroyed at the seat of the disease. (Case recorded by Bing.)

In a case presenting typical symptoms of *syringomyelia* of twenty years' duration I found the vibrating sensation unaffected, though sensation for pain and temperature were lost.

In the various forms of *spinal syphilis*, and specially in Erb's chronic form—*syphilitic spastic spinal paralysis*—the vibrating sensation is sometimes lost on the legs at the early period before other forms of sensation have become affected.

In *compression myelitis* due to spinal *caries* at the earliest period often no anesthesia to touch, pain or temperature can be detected. In addition to pain in the back and root pains there may be only slightly impaired muscular power in the legs and slight changes in the reflexes; yet at this stage the vibrating sensation is often lost on the legs and anterior iliac spines, being then the only form of sensation impaired.

In *spinal meningeal tumor* loss of the vibrating sensation may be the first form of sensory loss, *i. e.*, at the early stage we may find loss of the vibrating sensation on the legs while sensation to touch, pain and temperature are then unaffected. We have often, in the development of the symptoms of spinal meningeal tumor, a brief period at first in which paresis or paralysis of the legs is detected, but the reflexes are normal. The knee-jerks are normal and no ankle-clonus and no Babinski reflexes can be detected, and sensation of touch, pain and temperature are felt readily. In such cases the question of hysteria or functional affections may arise. But at this period we may find the vibrating sensation lost on the legs, and this would then be a sign in favor of organic disease. In these cases a Babinski reflex is soon obtained, ankle-clonus develops and anesthesia to touch, pain and temperature is afterward detected below the lesion.

In *compression myelitis from injuries* to the spine, and in other forms of traumatic lesion of the spinal cord, the upper limit of the anesthesia produced often indicates the localization of the lesion.

In *incompletely transverse lesions*, however, the sensation for touch and pain may not be lost, but the vibrating sensation alone may be lost below the lesion (on the bones of the legs and on the abdomen). On the skin of the abdomen the vibrating sensation may then be used to determine the upper limit of the sensory dis-

turbance and may thus be of localizing value (as pointed out by Dr. Gordon Holmes.)<sup>1</sup>

In *cerebral* diseases I have never found the vibrating sensation affected alone or before other forms of sensation. When other forms of sensation are lost the vibrating sensation may also be lost, but it appears to be affected to a less extent than sensation to touch, pain or temperature. Also in recovery from anesthesia due to cerebral disease the vibrating sensation appears to return before other forms of sensation.

In *hysteria*, *functional affections*, *neurosis*, *neurasthenia* and *malinger*ing I have never found the vibrating sensation lost when other forms of sensation were unaffected or unaffected after suggestion. In any case of paresis or paralysis of the legs, if the vibrating sensation is lost while other forms of sensation are recognized readily, and if the patient persists in this statement in spite of suggestions to the contrary by the wording of the questions, then hysteria or malingering is very improbable. In these conditions if the vibrating sensation is lost other forms of sensation will also be affected, or after suggestion, by the form of the questions, the patient will state that they are affected.

In a case of *localized paralysis* in a limb, if the vibrating sensation is lost and other forms of sensation are felt, or lost, a lesion of a peripheral nerve or nerve trunk can be excluded as the cause of the paralysis. In a case of localized paralysis, if the vibrating sensation is lost and other forms of sensation are recognized, and the patient persists in this statement in spite of suggestions to the contrary, then hysteria or malingering is very improbable.

In any case of *hemianesthesia*, if the vibrating sensation is not felt when the foot of the vibrating tuning-fork is placed on the edge of the sternum on the side of the tactile anesthesia, but felt when placed at a corresponding point on the other side, the case is one of hysteria or functional disease or malingering. (When the vibrating sensation is felt when the vibrating tuning-fork is placed on either side of the sternum no conclusion can be drawn from this fact as to the diagnosis.) In cases of hemianesthesia due to organic disease, if sensation is impaired over the sternum at all, when the tuning-fork is placed over the half of the sternum on the anesthetic side the vibrations would be transmitted across to the other half of the sternum and would at least be felt there. In all cases examined by myself, if due to organic disease, the tuning-fork vibrations have been felt when the tuning-fork has been placed on either half of the sternum.

The vibrating sensation may also be of service in a similar manner in the diagnosis between functional and organic *anesthesia limited to a portion of a limb*, as I have elsewhere described in the following words:<sup>2</sup>

<sup>1</sup> British Med. Jour., November 29, December 4 and 11, 1916.

<sup>2</sup> Rev. Neurol. and Psych., November and December, 1918.

"If the anesthesia is limited to a portion of a limb or one portion of the body, and if a long bone such as the tibia, ulna, femur or sternum is situated partly in the anesthetic area and partly in the non-anesthetic area, then the following test is occasionally of diagnostic service: If we find that the vibrating sensation is not felt *anywhere*, when the foot of a large vibrating tuning-fork is placed on a subcutaneous part of the bone just within the area of anesthesia, but the vibrations are felt when the foot of the vibrating tuning-fork is placed on the subcutaneous part of the bone just outside the area of cutaneous anesthesia, then the case is one of functional anesthesia (hysteria, malingering or 'idea' anesthesia). (If the vibrating sensation is not felt at both these points, no conclusion can be drawn from this symptom alone.)

"In the normal condition, when the foot of a large and suitable vibrating tuning-fork is placed on the subcutaneous surface of one end or one part of a bone, the vibrations are transmitted all over the bone, and are felt, though with diminished intensity, at distant parts of the bone. Hence if the foot of the vibrating tuning-fork is placed on the bone just within the limit of the anesthesia, though the vibrating sensation may not be felt at that point, the vibrations will be transmitted to other parts of the bone and should be felt there if the vibrating sensation of the other part or parts is not lost. If we find, therefore, that the vibrating tuning-fork is felt just outside the limit of the anesthetic area, this indicates that the vibrating sensation is not lost in the bone at this point, and therefore the transmitted vibrations should be felt *there* when the foot of the vibrating tuning-fork is placed within the anesthetic area."

In a case of *pernicious anemia* I have found the vibrating sensation lost though no other indications of lesion of the nervous system could be detected, but the patient complained of a sensation of numbness in the legs. (Probably spinal changes were commencing.)

In cases of *gangrene* of the toes associated with diabetes mellitus, and in cases of *perforating ulcer* of the foot associated with tabes or diabetes mellitus, we often find the vibrating sensation lost on the legs. The loss of this sensation is then due not to the gangrene or perforating ulcer but to the diabetes or tabes.

The remarks which I have made are sufficient to show the value of the vibrating sensation in the diagnosis of nervous diseases and to indicate that it is desirable to test this sensation in all cases in which a detailed examination of the nervous system is undertaken.

The following are common combinations of early signs of organic disease:

1. Loss of the vibrating sensation on the legs, slight incoördination, Babinski reflexes. (Later signs of ataxic paraplegia or combined posterolateral sclerosis or degeneration.)

2. Loss of the vibrating sensation on the legs or on the abdomen and legs or on the abdomen only. Babinski reflexes, loss of abdominal reflexes. (Later signs of disseminated sclerosis.)

3. Girdle pains, often for a long period; then loss of vibrating sensation on the legs, with Babinski reflexes. (Later signs of compression myelitis from tumor of the meninges or vertebrae.)

4. Loss of the vibrating sensation, loss of the tendo-Achillis reflexes, pain in the legs. (Later loss of knee-jerks and other symptoms of peripheral *multiple* neuritis.)

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### THE RELATIONSHIP BETWEEN CENTRAL AND PERIPHERAL INVOLVEMENT OF THE CRANIAL NERVES.\*

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IN the brief time assigned to me it is obviously impossible to deal with all the symptoms caused by endocranial involvement of the cranial nerves. I have therefore selected for consideration some of the symptoms of cranial nerve involvement which present unusual difficulties in diagnosis and about which our knowledge is still incomplete. I propose to confine my remarks to the first, second and eighth nerves and those portions of the fifth and ninth nerves which are concerned with taste. In other words, I am going to consider the cranial nerves that control the special senses in which you are particularly interested.

The various studies that have been carried on to locate the cerebral centers controlling the special senses have cleared up many points that have hitherto been shrouded in mystery, but there still remain a goodly number on which light needs to be thrown. But whether the loss of one of these functions is due to destruction of the end-organ, the cerebral pathways or center is still often most perplexing. You see a large number of such cases where we see *one*. If it would be possible to create a uniform method of study of all such cases, then a Gunn, a Helmholtz or a Hughlings-Jackson, or even a lesser light, might take this vast material, which both in quality and quantity has never hitherto been dreamed of, and cull from it most valuable information. The study of these special senses is beset with unusual difficulties, for here we are dealing with sensory phenomena which are difficult to throw light upon by any experimental observations on animals, since obviously

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